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(54) SPLINED ARTICULATED SPINDLE

(71) We, SIEMAG SIEGENER MASCHINENBAU G.m.b.H., a German Company, of 5912 Hilchenbach-Dahlbruch, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a splined articulated spindle, such as is used for coupling the rolls of rolling mills or the like with the driving pinions of rolling mills, comprising a spindle shank having at each end a barrel-tooth central member of a splined coupling, such member so engaging in internal toothing of a sleeve around the spindle as to be in operative and positive engagement with such sleeve with freedom for angular movement.

Spindles of this kind are used in association with roll stands to enable the nip to be varied without disturbing the drive. As the nip varies, the spindle shank is displaced angularly relatively to the spindle-surrounding sleeves, for instance, over a range of from about 1 to 4°. Due to this angular displacement of the shank relatively to the sleeves, the effect on the drive motion for the spindles is that the internal toothing of the sleeves moves relatively to the external toothing of the central members of the splined couplings. The continual sliding motion between these two tooth systems evolves considerable heat. Unfortunately, the temperature difference between those parts of the spindle which heat up and the ambient air is usually too small for satisfactory heat removal by radiation, with the result that overheating occurs, leading to heavy wear of the spindle parts and even to the breakage of tooth flanks.

To reduce sliding friction between the two meshing tooth systems, it is known to fill the whole spindle head with grease. Unfortunately, this step fails to prevent overheating in the spindle head, for heat which is received by the grease in the zones of sliding engagement between the two tooth system is distributed unsatisfactorily through the rest of the grease, and so there is a temperature drop in the actual grease.

To ensure satisfactory cooling in addition to satisfactory lubrication, it is known for the spindle heads to be oil-filled. The advantage of an oil filling over a grease filling is that oil which is heated by the sliding movement between the two tooth systems mixes uniformly with the remainder of the oil in the spindle head, so that the oil temperature is relatively uniform throughout. A disadvantage, however, is that extra rubber bellows seals must be used, and the continual pressure while the spindles are in operation, not to mention external factors, may readily damage such seals. The reliability of spindles of this kind in operation is therefore unsatisfactory.

It is an object of this invention to improve articulated splined spindles of the kind specified so that the spindle head can be given once-through lubrication, with the result that the heat evolved in the spindle head can be removed continuously by a continuous supply of cool oil and a continuous removal of hot oil.

According to the invention there is provided a splined articulated spindle, comprising a spindle shank having at at least one end a barrel-tooth central member of a splined coupling, such member so engaging in internal toothing of a sleeve around the spindle as to be in operative and positive engagement with sluch sleeve with freedom for angular movement, said splined articulated spindle including a non-rotatably supported casing which extends circumferentially around, and at a distance radially from, the spindle shank near the or each splined articulation and within such casing an annular member mounted on the spindle shank in rotatable sealing-tight relationship therewith and formed on its inner periphery with an annular channel which communicates with an oil supply line and into which annular channel one or more radial oil ways (as herein defined) in the spindle shank ex-

tend, one or more longitudinal oil ways in the spindle shank communicating with the or each radial oil way in the spindle shank and extending, in the engagement zone between the central member of the splined coupling and the spindle-surrounding sleeve, into a space in the sleeve, such space being in leak communication with the casing interior by way of deflectors which are disposed on the spindle-surrounding sleeve and which extend into the casing and an oil discharge way being connected to the casing and being adapted to be connected, preferably via cooling means, with the inlet side of a pump or similar facility whose delivery side is connected to the oil supply line.

The term "radial oil way" as used herein means an oil way which extends in a direction having a radial component with respect to the spindle shank.

Preferably, to reduce loss of oil from the casing, the casing is formed, in the region where the spindle shank extends through it, with lamella-like walls between which lamella-like rings on such shank engage with clearance in labyrinth-fashion. Preferably, the deflectors of the spring-surrounding sleeve engage by way of one or more lamella-like flanges behind the casing wall near such sleeve.

These steps considerably reduce oil losses from the casing.

Preferably, at both ends of the shank, each spindle engages in spindle-surrounding sleeves by way of central members of splined couplings. Conveniently, near the ends of the spindle shank the longitudinal oil ways have their cross-section reduced by nozzle inserts, a chamber being left behind each nozzle insert, a number of branch oil ways branching from such chamber to the space between the central member of the splined coupling and the spindle-surrounding sleeve. This step ensures uniform distribution of the oil providing lubrication and cooling in the space between the two parts of the splined coupling, so that heat removal is satisfactory.

An embodiment of the invention will now be described with reference to the accompanying drawings wherein:—

Figure 1*a* is a view in side elevation, with partial sectioning of a pair of splined articulated spindles forming a drive coupling for a roller mill disposed between a pinion stand and a roll stand, said view showing the ends of said spindles adjacent the roll stand;

Figure 1*b* is a view of the spindles of Figure 1 showing the ends of said spindles adjacent the pinion stand, and

Figure 2 is a section on the line II—II of Figure 1*a*.

Two splined articulated spindles A, B forming a pair are of identical construction, each having a spindle shank 1 having rigidly secured to each end, so as to rotate with the shank 1, a central member 2 of a splined coupling, member 2 having an outer tooth system 3 comprising barrelled teeth. The outer teeth 3 of each member 2 are engaged by straight internal teeth 5 of a spindle-surrounding sleeve 4, the engagement being operative and positive so as to provide a rotating drive. Each member 2 and associated sleeve 4 together form a spindle head 6 permitting limited angular displacement e.g. over a range of from 1½ to 4°, between the longitudinal axis of shank 1 and the longitudinal axis of sleeve 4.

As Figure 1*b* shows, each of the two spindles A, B is in driving engagement by way of one of its spindle heads 6 with a pinion stand K serving as a drive device. As Figure 1*a* shows the other spindle head 6 of each spindle engages by way of its casing 4 with roll necks W of the rolls of a roll stand (Figure 1*a*). The between-axes distances of the pinions of stand K never vary, but the between-axes distances of the work rolls can vary according to roll diameter and to variations in the size of the roll nip. The purpose of the splined articulated spindles A, B is to enable the between-centres distance of the work rolls to vary while maintaining the driving engagement between the necks W of the work rolls and the pinions of the pinion stand.

The relative movement between the sleeve teeth 5 and the outer teeth 3 of member 2, caused by the angular displacement of the axis of shank 1 relatively to the axis of the sleeve 4 as the spindles A and B rotate, leads to considerable evolution of heat in the spindle heads 6. To prevent overheating from causing heavy wear and to reduce the risk of tooth flank breakages, the spindle head 6 is given once-through oil lubrication; the oil flowing through the head 6 also removes heat uniformly therefrom—i.e. cools the heads 6.

So that the spindle heads 6 at the ends near the roll stand can be given once-through lubrication, a casing 7 extends around each of the two spindles A, B near such heads 6. The casing 7 cannot rotate with the associated spindle but can follow the angular displacement of the shank 1 relatively to the sleeve 4 at the end near the roll stand. Disposed in each casing 7 is an annular member 8 which, as reference 9 in Figure 2 shows, is rigidly connected to the casing. Member 8 extends around the corresponding shank 1 and is formed on its inner periphery with an annular channel 10 sealed off from the periphery of shank 1. Channel 10 communicates permanently with a pressure oil supply line 11, and the shank 1 of each spindle A, B has radial oil ways 12 which extend into annular

channel 10 of member 8. Oil ways 21 are in permanent flow communication with a longitudinal oil way 13 in shank 1. Oil way 13 extends through shank 1 over the whole length thereof. Disposed in oil way 13 some distance before each end of shank 1 are nozzle inserts 14 which extend into a chamber 15 whence a number of oil ways 16 extend to the end face of shank 1, terminating in a space 17 bounded by sleeve 4 and member 2, the sleeve teeth 5 extending into space 17.

The sleeve end near casing 7 has deflectors 18 which extend into casing 7 from the side.

When the rolling mill is in operation, oil at a pressure of e.g. from 1 to 1.8 atmospheres gauge, is introduced through line 11 into annular chamber 10 of member 8, goes from channel 10 through radial oil ways 12 into longitudinal way 13 of shank 1, and flows in both directions to the nozzle inserts 14 which reduce the cross-section of way 13 and thus cause the oil to back up. The oil then goes through inserts 14 to a chamber 15 and therefrom through oil ways 16 to space 17; from space 17 the oil passes between the flanks of the teeth of the two tooth systems 5, 3 to lubricate the same. The oil then flows along deflector 18 which provides a leakage exit directly to casing 7. At its lowest part, casing 7 is connected to an oil return line 19 which supplies e.g. to a cooler, the oil collecting in casing 7. The cooler can be followed by a pump whose delivery side is connected to the oil supply line 11. There is therefore continuous oil circulation which ensures satisfactory lubrication of the tooth systems of head 6 and removes heat efficiently therefrom too.

As Figures 1*a* and 1*b* show, independent casings 7 are associated only with those spindle heads 6 of the two spindles A, B which are near the rolls. The pinion-side heads 6 on the other hand, extend into a common casing 20.

As Figures 1*a* and 1*b* also show, the casings 7, 20 have, in the region where shank 1 extends through them, lamella-like walls 21 between which lamella-like rings on shank 1 engage in labyrinth-fashion with axial clearance. This ensures that the oil collecting in casings 7, 20 is not hurled outwards. Similarly, the deflectors 18 of the sleeves 4 have radial flange parts which engage behind the casing wall near the spindle-surrounding sleeve 4.

Referring to Figure 2, the casings 7 associated with the roll-sided spindle heads 6 are mounted on common guide bars 24 for vertical movement and for axial movement relatively to one another, the bars 24 preventing any rotation of casings 7 with the spindles A, B.

WHAT WE CLAIM IS:—

1. A splined articulated spindle, comprising a spindle shank having at at least one end a barrel-tooth central member of a splined coupling, such member so engaging in internal toothing of a sleeve around the spindle shank as to be in operative and positive engagement with such sleeve with freedom for angular movement, said splined articulated spindle including a non-rotatably supported casing which extends circumferentially around, and at a distance radially from, the spindle shank near the or each splined articulation and within such casing an annular member mounted on the spindle shank in rotatable sealing-tight relationship therewith and formed on its inner periphery with an annular channel which communicates with an oil supply line and into which annular channel one or more radial oil ways (as herein defined) in the spindle shank extend, one or more longitudinal oil ways in the spindle shank communicating with the or each radial oil way in the spindle shank and extending, in the engagement zone between the central member of the splined coupling and the spindle-surrounding sleeve into a space in the sleeve, such space being in leak communication with the casing interior by way of deflectors which are disposed on the spindle-surrounding sleeve and which extend into the casing; and an oil discharge way being connected to the casing and being adapted to be connected preferably via cooling means, with the inlet side of a pump or similar facility whose delivery side is connected to the oil supply line.

2. A spindle as claimed in claim 1, in which said casing is formed, in the region where the spindle shank extends through it, with lamella-like walls between which lamella-like rings on such shank engage in labyrinth-fashion with clearance.

3. A spindle as claimed in claim 1 or claim 2, in which the deflectors of the spindle-surrounding sleeve extend by way of radial flange parts behind the casing wall near such sleeve.

4. A spindle as claimed in any of claims 1 to 3, in which the spindle shank has such a splined coupling at each end thereof and wherein the or each longitudinal way extends to both ends of the spindle shank.

5. A spindle as claimed in any of claims 1 to 4, in which near the or each said end of the spindle shank the longitudinal oil ways have their cross-section reduced by nozzle inserts, a chamber being left behind each nozzle insert and a number of branch oil ways extending from such chamber to the space between the central member of the splined coupling and the spindle-surrounding sleeve.

6. A driving coupling for the rolls of a

rolling mill comprising for each roll of the mill a spindle as claimed in claim 4 or claim 5 when dependent thereon the sleeve adjacent one end being adapted to be fixed to the roll spindle and the sleeve adjacent the other end being adapted to be fixed to a driving pinion, the annular member formed with the annular channel and the radial oil ways extending from such channel in the spindle shank being disposed near the end of the spindle engaging the sleeve adapted to be fixed to the roll spindle.

7. A driving coupling as claimed in claim 6, in which a plurality of such spindle shanks extend into a common casing on the side adapted to be connected to their respective driving pinions, whereas a separate casing extends around each spindle shank on the side adapted to be connected to the respective rolls.

8. A driving coupling as claimed in claim 6 or claim 7, in which a plurality of casings disposed one above another are mounted on common guide bars for vertical and longitudinal movement.

9. A spindle substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

10. A driving coupling for a rolling mill, substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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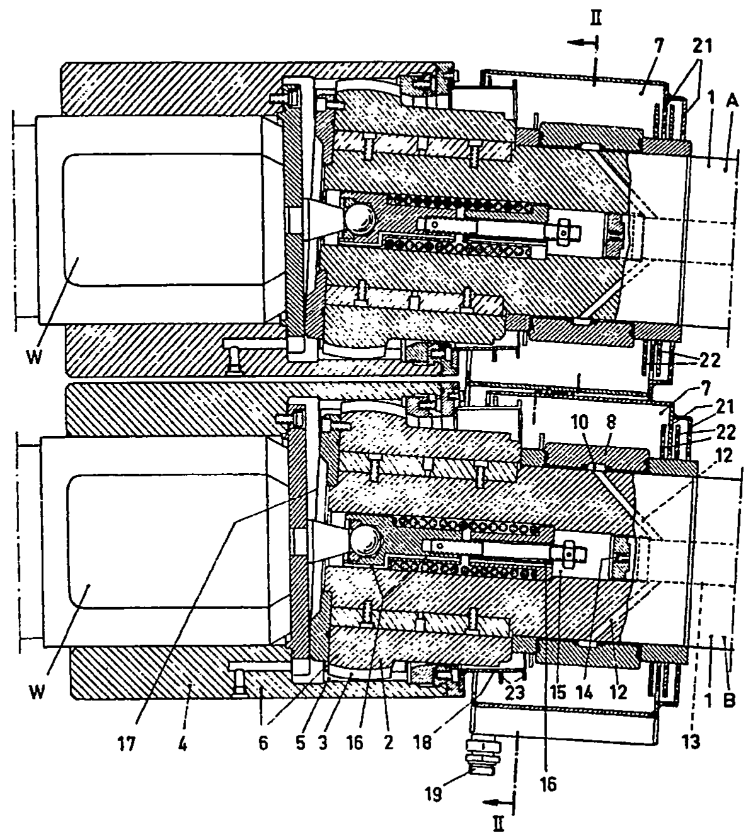
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig. 1a



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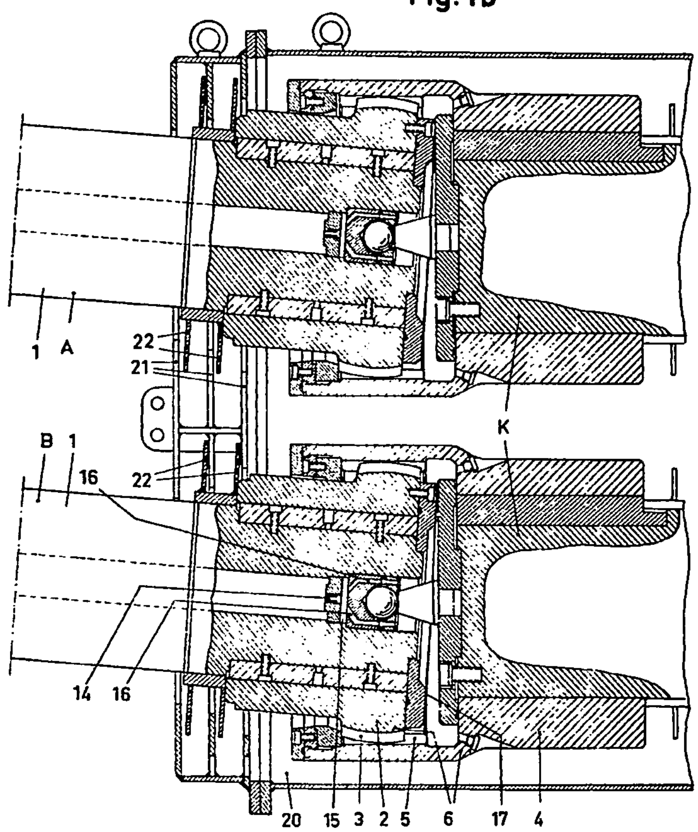
Sheet 2

Fig. 1b



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Sheet 3

Fig. 2